Bringing ecosystem thinking to sustainability-driven wooden construction business

Viholainen, Noora

2021-04-10

Viholainen , N , Kylkilahti , E , Autio , M , Pöyhönen , J & Toppinen , A 2021 , ' Bringing ecosystem thinking to sustainability-driven wooden construction business ' , Journal of Cleaner Production , vol. 292 , 126029 . https://doi.org/10.1016/j.jclepro.2021.126029

http://hdl.handle.net/10138/328905
https://doi.org/10.1016/j.jclepro.2021.126029

Journal of Cleaner Production 292 (2021) 126029

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Bringing ecosystem thinking to sustainability-driven wooden construction business

Noora Viholainen [a], Eliisa Kylkilahti [b], Minna Autio [c], Juho Pöyhönen [a], Anne Toppinen [a, *]

[a] Department of Forest Sciences, University of Helsinki, Helsinki, Finland
[b] Department of Economics and Management, University of Helsinki, Helsinki, Finland
[c] Department of Education, University of Helsinki, Helsinki, Finland

ARTICLE INFO

Article history:
Received 7 November 2019
Received in revised form
10 January 2021
Accepted 17 January 2021
Available online 19 January 2021

Handling editor: Yutao Wang

Keywords:
Sustainability
Business ecosystem
Wood
Innovation
Learning
End-user involvement

ABSTRACT

Lowering environmental impacts by material choices is proposed as a way to promote urban sustainability transition, and one solution is building more wooden multi-storey constructions (WMCs). In the construction industry, however, there is a strong path dependency towards applying well-established construction materials and methods, as well as partnerships. To gain understanding of network-based collaboration, learning and end-user involvement in novel wooden construction business, the study uses qualitative methods and employs business ecosystem approach in the analysis. The studied WMC business case revealed that barriers of collaborative business ecosystem development include both the lack of clarity in the shared goals between actors and weak end-user involvement. Moreover, neither companies nor end-users fully recognize sustainability aspects around WMC. Enabling factors such as smooth communication and building trust among business actors during planning and building were recognised. The study suggests that a broader business ecosystem approach, including the living and use of the building, offers a mindset shift for developing sustainability-driven logic alongside profitable construction business and creating value for consumers.

1. Introduction

The construction industry has considerable potential to contribute to a sustainability transition in the "1.5-degree world" (IPCC, 2018). Globally, construction is seen as one of the most carbon-intensive sectors, emitting more than 20% of the yearly CO_2 emissions originating from global economic activities (Huang et al., 2018). The residential sector represents 27% of global energy consumption and 17% of CO_2 emissions (Nejat et al., 2015). Current construction practices, such as design and engineering methods, construction techniques, and manufacturing technology must therefore change (Dixit et al., 2010, Wang et al., 2014).

The potential of engineered wood products, such as cross-laminated timber, as sustainable, low-carbon building materials has been recognized worldwide (Lehmann, 2013). For example, these products combined with updated building regulations (e.g. related to fire protection) have supported the recent increase in wood use, also in multi-storey building applications in Europe (Hildebrandt et al., 2017). This growing interest towards wooden multi-storey construction (hereafter WMC) may also be attributed to low costs, rapid construction, and aesthetics (Gosselin et al., 2017). Furthermore, WMC enables industrialized prefabrication, i.e. the manufacture of construction elements and components mostly off-site, which may improve material efficiency and reduce the greenhouse gas emissions of construction (Hurmekoski et al., 2018; Toppinen et al., 2018).

This study focuses on Finland, where WMC has proven to be the most evident new business opportunity in the emerging bio-based economy (Toppinen et al., 2018) and several WMC promotion programmes have been carried out by the Finnish government since the mid-1990s (Hurmekoski et al., 2015, see also Lazarevic et al., 2020). While the number of WMC projects has increased during past years, they are still considered to be in the piloting phase (Lazarevic et al., 2020). According to Franzini et al. (2018), Finnish WMC business is characterized to suffer from a vicious circle, in which the small number of actors and available skills results in limited demand, which in turn hinders new actors from entering the business. Wooden multi-storey construction currently only has a 6% market share in Finland (Hurmekoski et al., 2018), despite wood being the main structural material of single-family houses and vacation homes in the country.

The conservativeness of the construction industry (Hurmekoski et al., 2015) and its strong path dependency

* Corresponding author. Mail: P.O. Box 27, 00014, University of Helsinki, Finland.
E-mail address: anne.toppinen@helsinki.fi (A. Toppinen).

https://doi.org/10.1016/j.jclepro.2021.126029

(Mahapatra and Gustavsson, 2008) favouring concrete as a dominant raw material are root causes for the low market share of WMC (Hemström et al., 2017). This is illustrated in the reluctance to adopt new methods or materials that usually involve more risk-taking and unforeseen costs (Gann and Salter, 2000; Häkkinen and Belloni, 2011). Learning and collecting feedback is hindered by the industry's project-based nature (Gann and Salter, 2000), thus leading to slower knowledge accumulation (Mokhlesian and Holmén, 2012), which is important when implementing new materials and methods such as WMC.

Furthermore, while collaboration and communication have been regarded as key elements in increasing organizational innovativeness and sustainability, they are not typically emphasized in the construction sector culture (Ruuska and Häkkinen, 2016; Matinaro and Liu, 2017; Gosselin et al., 2018). Limited interest has also been shown in collaborating with actors or stakeholders external to the core project (Bygballe and Ingemansson, 2014), such as end-users. However, Martek et al. (2019) recently emphasized that the transition to a more sustainably built environment requires understanding end-user roles in generating demand for more sustainable residential buildings. According to Gosselin et al. (2018, p. 2): "even though the supply chain structure for timber buildings is well-known, the interrelationships between stakeholders represent a great research opportunity".

In this study, we apply the *business ecosystem* (BE) concept as a tool for analysing collaboration in the WMC context, with a focus on how the project-based construction industry introduces sustainability-driven innovations into their network. The business ecosystem concept (Moore, 1993) has been suggested to offer a mindset shift in the construction industry, as it highlights inter-organizational collaboration and learning as a means to help companies innovate and adapt to future change together (Pulkka et al., 2016; Williamson and de Meyer, 2012). Business ecosystems, as Moore (1998) describes, are communities to which members, such as producers, suppliers, customers, and financiers, bring complementary inputs that are utilized to create innovations and value. Therefore, a business ecosystem represents an opportunity to study the interdependence and dynamism between project actors beyond traditional networks (Aarikka-Stenroos and Ritala, 2017).

Pulkka et al. (2016) demonstrated the applicability of the business ecosystem concept in the construction industry setting and proposed its positive impact on value creation in the construction business. Our study aims to deepen the business ecosystem literature by applying this concept to the WMC business environment, which provides a prime setting for analysing an emerging, sustainability-driven construction business. Our analysis focuses on collaborative learning concerning new innovative building practices, along with the question of end-user involvement levelsin the business ecosystem. Three specific research questions (RQs) are outlined as follows:

RQ1: How do business ecosystem actors co-operate and learn about building with wood as a low-carbon material?

RQ2: How do business actors include end-user expectations and knowledge into the project?

RQ3: Which enablers and barriers related to the business ecosystem approach influence collaboration in the sustainability-driven WMC business?

The contextualization and analytical framework is built on a literature review in Section 2, followed by a description of empirical data collection and methods in Section 3, and by the Results in Section 4. Our results will be discussed in Section 5, and the paper ends with identification of future research needs and concluding comments in Section 6.

2. Conceptual framework: business ecosystem approach to WMC

Moore (1993, p.76) describes the business ecosystem concept as: "In a business ecosystem, companies co-evolve capabilities around a new innovation: they work co-operatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations." The concept emphasizes collaboration; most products and services are a result of collective efforts between several specialized actors, whose individual offerings do not possess value until combined with the efforts of others (Iansiti and Levien, 2004; Thomas and Autio, 2014). Ecosystem members should thus continuously improve on their own capabilities, while concurrently actively relating with other actors to co-evolve withing the network (Moore, 1998). The keystone player (a lead firm or hub) is the focal organization of the business ecosystem: it creates value within the ecosystem, shares it with other actors, and attracts new niche actors (Iansiti and Levien, 2004). The keystone also aims to constantly improve ecosystem productivity through, for example, enabling the smooth exchange and codification of data and knowledge, encouraging trust-building, and governing the ecosystem with both norms and contracts (de Meyer and Williamson, 2020). Further co-evolutionary logic differentiates the business ecosystem concept from more traditional project relationships and networks, along with its increased interdependency, dynamism, and stability (Aarikka-Stenroos and Ritala, 2017). Additionally, the concept includes both production- and user-side participants (Moore, 2006; Thomas and Autio, 2014).

The business ecosystem concept has, however, encountered criticism, mainly due to the existence of several somewhat overlapping terms being used in the literature, namely innovation, knowledge, platform, service, entrepreneurial, and digital ecosystems, with studies seeking to compare the differences between the concepts in order to standardize their use and thus reduce confusion (see e.g. Clarysse et al., 2014; Valkokari, 2015; Aarikka-Stenroos and Ritala, 2017; de Vasconcelos Gomes et al., 2018; Aksenova et al., 2019; Gupta et al., 2019).

The innovation ecosystem (e.g. Adner and Kapoor, 2010), based on Moore's (1993) business ecosystem concept, has gained particular interest in recent research (de Vasconcelos Gomez et al., 2018). Similarities exist between the innovation and business ecosystem concepts, such as a strong presence of various interaction types between ecosystem members, a hub firm that efficiently orchestrates knowledge sharing, and an aim to generate innovation. However, the business ecosystem concept emphasizes network collaboration and co-evolution (Aarikka-Stenroos and Ritala, 2017; Gupta et al., 2019) and value generation for the customer (Clarysse et al., 2014) to a higher degree, while the innovation ecosystem is aimed more towards generating knowledge (Clarysse et al., 2014) and relates to topics on science and technology (Gupta et al., 2019).

While the business ecosystem concept was initially mostly applied to high-technology sectors (i.e. computer and communications technology), the concept has since spread further (Moore, 2006). Recent research examples include studies on sea shipping ecosystems (Eriksson et al., 2019) and oil and gas production ecosystems (Masucci et al., 2020), and the concept has also been studied in connection to sustainability such as the circular economy (Hsieh et al., 2017) and urban low-carbon transportation (Ma et al., 2018).

Our study contributes to the business ecosystem literature from a perspective that examines the material-based sustainability transition in the construction industry. The construction industry possesses certain characteristics that may complicate the uptake of new products and methods. Firstly, while actors in construction

projects are required to collaborate and interact to fit their components together, the "systematic combining of resources between specific companies that change jointly", which is required for long-term change and innovation, is not common among construction companies (Håkansson and Ingemasson, 2013, p. 43–44). The industry is project-based in nature, aiming to produce one-off or highly customized products and services, making it challenging for the companies to transfer knowledge and to learn and continuously innovate at both the inter- and intra-organizational levels (Gann and Salter, 2000). Lappi et al. (2017) provide a good illustration on the importance of a front-end phase preceding the operational ecosystem via an anchoring organization. This aspect is lacking in mainstream business ecosystem literature, but we touch upon it in this study.

Secondly, a business ecosystem can also "foster co-learning and catalyse innovation", with the lead firm having an important role in harnessing the abilities of a diverse set of ecosystem members, facilitating knowledge sharing, and encouraging both individual and joint innovation (de Meyer and Williamson, 2020, p.117). We thus argue that while a certain level of complementariness and collaboration exists in all construction projects, the business ecosystem concept provides further impetus for building interconnectedness and longer-term commitment into the industry, including knowledge sharing. It should be noted, as Wulf and Butel (2017) present in their research, that collaboration and knowledge sharing in business ecosystems is affected by the structure and richness of the network, the actors' positions in the network, along with how the ecosystem is governed.

Thirdly, communicating with consumers is crucial for the diffusion of WMC in the housing market (e.g. Lähtinen et al., 2019), yet user considerations are rare in conventional building procurement processes (Vischer, 2008). For example, when a consumer buys an apartment in a multi-family building in Finland, individual preferences are actualized in the consumer choices of pre-selected furnishings and decorating solutions such as kitchen fittings or flooring materials (e.g. laminate or parquet) (Autio and Autio, 2013). Yet, Pemsel et al. (2010) have recognized several additional opportunities for exploring end-user needs in the design and delivery of construction projects, such as organizing resident meetings, workshops, and by collecting customer feedback during or after residents have move in. According to Eriksson et al. (2015), user involvement in residential building processes has many benefits also for (current or future) residents such as increasing the feelings of ownership.

Considering the construction material, homebuyers may be more inclined to favour materials they are familiar with (Høibø et al., 2018), and although end-users may have positive associations with wood as a construction material, including well-being, eco-friendliness, and aesthetics, these feelings are not sufficiently strong to trigger higher appreciation towards wood as a construction material (Gold and Rubik, 2009). Additionally, end-users may have individual prejudices towards wood, related to its perceived poor fire safety and higher maintenance costs (see for example Høibø et al., 2015; Larasatie et al., 2018; Lähtinen et al., 2019).

Consumers have been presented as being part of the ecosystem in the business ecosystem literature, yet their level of inclusion is somewhat unclear (see also Koenig, 2012). Moore (2006) has presented consumers in a traditional sense as passive buyers, who provide feedback to the ecosystem in the form of purchaces, which is also common in construction projects. On the other hand, in one of the few studies exploring the customer/consumer role in business ecosystems, Joo and Shin (2018) indicate that consumers may have a larger role in an ecosystem, depending on the product or service provided by that ecosystem. For example, they may function as content creators. Baldassarre et al. (2017) suggest that the development of solutions that are mutually meaningful for people and profitable for business requires the involvement of potential end-users. Therefore, with our study, we contribute to the limited number of studies considering the role of consumers in business ecosystems, especially when introducing them to a novelty such as WMC. Table 1 summarizes the main theoretical concepts and the key literature used in the study.

Previously, Pulkka et al. (2016) applied the business ecosystem concept to the context of the construction industry by basing their study on Thomas and Autio's (2014) three business ecosystem characteristics, which create customer value collectively. The characteristics include a *network of participants* (i.e. specialization, complementariness, and co-evolution), a *governance system* (i.e. authority structure, membership control, and task coordination), and *shared logic* (i.e. legitimacy, trust, and mutual awareness). The network of participants consists of actors, each possessing unique, complementary competencies and co-evolving, i.e. developing together, to meet the changing requirements set by the environment they function in. The governance system determines which companies may participate in the collaboration, how the tasks are organized, and who decides them. Finally, the shared logic focuses on the legitimacy of the business ecosystem, in which trust and mutual awareness between participants play a key role (Thomas and Autio, 2014; Pulkka et al., 2016). By continuing in their footsteps and viewing WMC through the above-mentioned three elements, we aim to better understand the nature of emergent business ecosystems and how the ecosystem actors interact when dealing with novel, sustainable building materials, and whether and how end-users engage in the business ecosystems. We therefore acknowledge the importance of both production and consumption side participants for value creation, alike demonstrated by Fig. 1.

3. Data and methods

3.1. Empirical data

The studied case illustrates how a sustainability-driven innovation is introduced into the design and construction phases of a case project. The building constructed in the project is a two-storey multi-family building with 14 apartments, located in Finland, with wood as both the main structural and cladding material. The construction project in question was chosen due to the following main reasons: i) during the time of the study (March–May 2017), it was one of the few WMC projects in Finland managed by a private developer, ii) the project was still ongoing at the time of the study but close to completion, and all project actors and residents were therefore identifiable, and iii) researchers were granted access to project-level documentation. But most importantly: iv) the project entailed experimental aspects of WMC, which made it compatible with our aim of studying the phenomenon of learning in a pilot project. The experimental aspects were created first and foremost due to the aim of the main developer, which was to test new wooden flooring elements. Second, the developer had entered the construction industry only a few years earlier, with their main role being a wooden element provider to other construction projects. In the case project, however, the company had adopted a new role as the main developer, with high motivation to use this project as a learning platform.

To answer the research questions, we chose to interview the case project companies, future residents, and a municipality representative. Similar to Tunn et al. (2019), semi-structured interviews were chosen to gain in-depth insights of the business model. Semi-structured interviews enable increased interaction between the interviewer and interviewee, and exploring topics

Table 1
Key literature for studying the business ecosystem in the wood material based construction industry.

	Business ecosystem literature	Construction industry research	Wooden multi-story construction research
Roles and relations of co-operating actors: ***Keystone player*** ***Enlarged business*** ***Business ecosystem***	Thomas and Autio (2014); de Meyer and Williamson (2020); Iansiti and Levien (2004)	Pulkka et al. (2016)	Toppinen et al. (2019)
Collaborative learning	Aarikka-Stenroos and Ritala (2017); Williamson and de Meyer (2012)	Pulkka et al. (2016)	Toppinen et al. (2019); Lazarevic et al. (2020)
End-user involvement	Moore (2006); Thomas and Autio (2014); Joo and Shin (2018)	Eriksson et al. (2015); Pemsel et al. (2010); Vischer (2008)	Lähtinen et al. (2019); Viholainen et al. (2020)
Business ecosystem elements: ***Network of participants,*** ***Governance system,*** ***Shared logic***	Thomas and Autio (2014)	Pulkka et al. (2016)	Toppinen et al. (2019)

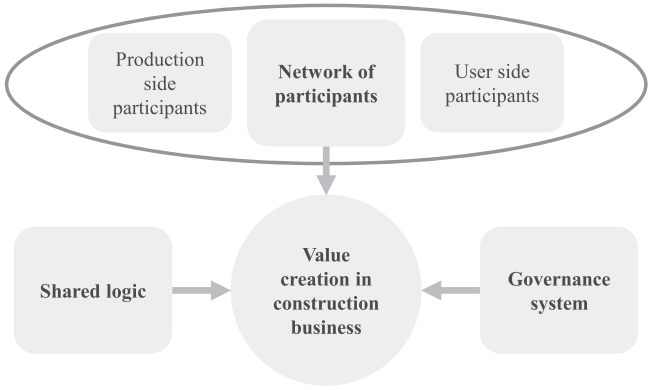

Fig. 1. Business ecosystem characteristics creating value in construction business (modified from Pulkka et al., 2016).

wider than the ones originally intended is also possible (Edwards and Holland, 2013). Two sets of semi-structured interview guides were designed (Appendix): one for the project actors (and municipality representative) and one for future residents (see Table 2). While the project actor interviews were used to collect data solely to study the business ecosystem from the project management context, the interview directed at future residents was mainly created to elicit information regarding the purchasing process experience (including communication with the developer and other project actors) and perceptions towards wood as a construction material.

The project actor interview guide was theory-driven based on a literature review and on the theoretical framework from the business ecosystem, including the use of propositions from Thomas and Autio (2014) and Pulkka et al. (2016), the roles suggested by Iansiti and Levien (2004), and the various ecosystem levels suggested by Moore (2006) and Gann and Salter (2000). Moreover, the interview guide for future residents (see Appendix) followed a data-driven approach to allow end-users to express their views on the novel construction material and their involvement in the project.

Project actors and the municipality representative were contacted by the researchers based on a description document of the case provided by the developer. All companies mentioned in the description document were willing to participate in the interviews and represented various fields of the construction business. Certain companies participated in multiple construction phases or otherwise the need arose for more than one key person to be interviewed. The project's estate agent contacted the future residents and asked whether their contact details could be given to the researchers. Eight people were recruited by the agent, five of which

Table 2
Information of the project actor and end-user interviews.

Type of member in business ecosystem	Number of interviews	Additional information on professional background (in case of residents their gender and age)	Interview method
Developer/main contractor	3	Director of planning, R&D and IT	Phone
		Element designer	Phone
		Main site supervisor	Face-to-face
Project actors	9	Architect	Phone
		Structural engineer (structures)	Phone
		Structural engineer (foundations)	Phone
		Heating, piping and air conditioning (HPAC) engineer	Phone
		Excavation and yard work	Phone
		Foundation work	Phone
		HPAC and electrical site supervisor (x 2)	Face-to-face
		Real-estate agent	Face-to-face
		Door and window supplier	Phone
Municipality representative	1	Zoning architect	Face-to-face
Future residents	7	Female, 29	Phone
		Male, 50	Face-to-face
		Female, 40	Face-to-face
		Female, 41	Face-to-face
		Female, 58	Face-to-face
		Male, 32	Phone
		Female, 28	Phone

were available and/or willing to be interviewed. Six remaining apartments were sold later that spring, and two of the homebuyers in this group participated in the interviews.

The interviewees consist of twelve company and one municipality representatives, and seven future residents, totalling 20 interviews (see Table 2). The interviews were conducted face-to-face when possible, otherwise via phone. Irvine et al. (2013) suggested that phone interviews are not as advisable as face-to-face interviews. However, the advantages of using a phone compared to face-to-face include saving time and travel costs, and phone contacts were necessary when certain interviewees were otherwise unreachable. The interviews averaged 65 min in length. All interviews were recorded, transcribed, and analysed. Table 2 shows the background information of the interviews. The number of female interviewees among the end-users is higher than the number of male interviewees. This is most likely due to women generally being more eager to participate in consumer interviews compared to men.

3.2. Data analysis and reliability assessment

We used thematic analysis to analyse the data, as it is a commonly used form of analysis in qualitative research based on interview data (Braun and Clarke, 2006). In the analysis, using an iterative approach, we first focused on themes that appeared across the project actor interviews, such as co-operation between partners, learning related to building with a novel wooden material, and end-user involvement. Second, we focused on future residents' experiences and perceptions towards wood and their perceptions of their own involvement in the project. Fig. 2 illustrates the coding and thematic data analysis process.

Thirdly, the data were examined considering the different project phases, namely design and construction. This helped to understand the collaboration and communication implemented during the design and construction phases between the actors. Based on this analysis, we were able to create a network map indicating the roles and relations of companies and other stakeholders, such as the keystone player and its relation to core companies and occasional partners. Eventually, we pictured the business ecosystem network in Fig. 3, and it is presented and discussed in the Results section.

The reliability of our study was ensured by carefully documenting the research process and its results, and by involving all participating researchers in analysing the findings. During the analysis process, we concluded that the interview data were sufficient for analysing the research questions, as most of the questions had recurring themes, and only marginal new information was obtained during the final stages of data collection. Our aim is to confirm the validity of the study through transparent communication of the data-gathering process and generous use of data excerpts in the following analysis section. We note that the objective of this qualitative interview study is not to present generalizable results of the case, but to understand the business ecosystem structure in the context of WMCs (see also limitations under section 5.4).

4. Results

4.1. Co-operation among business ecosystem actors

Illustrating the roles and relations of the actors, Fig. 3 pictures the main developer in the role of a keystone player while the partnering companies in its closest network form the enlarged business (see Heikkilä and Kuivaniemi, 2012; Moore, 1993). Furthermore, the business ecosystem approach considers the network of participants in a wider sense, for example, how the local municipality and future residents are positioned in this operational environment. The arrows in Fig. 3 illustrate the communicative relations recognized by the network participants and discussed in the interviews.

In our building project case, the developer initiated the project and *acted as the main constructor.* This role entailed coordination of several tasks, such as acquiring the plot and renting the case building site from the municipality, along with planning and coordinating the site. Being the main developer and project leader was an experimental endeavour for the company, as their core competence is designing, manufacturing, and installing wood elements for other construction projects. The Director of planning (DoP) explained the reason why they had chosen to act as the main developer:

> … we have strong R&D. And R&D includes product testing, which is why we tested them. We build a few buildings per year ourselves and test the new products, and this is the most rapid way for us to gain feedback. – Director of planning, R&D and IT, Main developer –

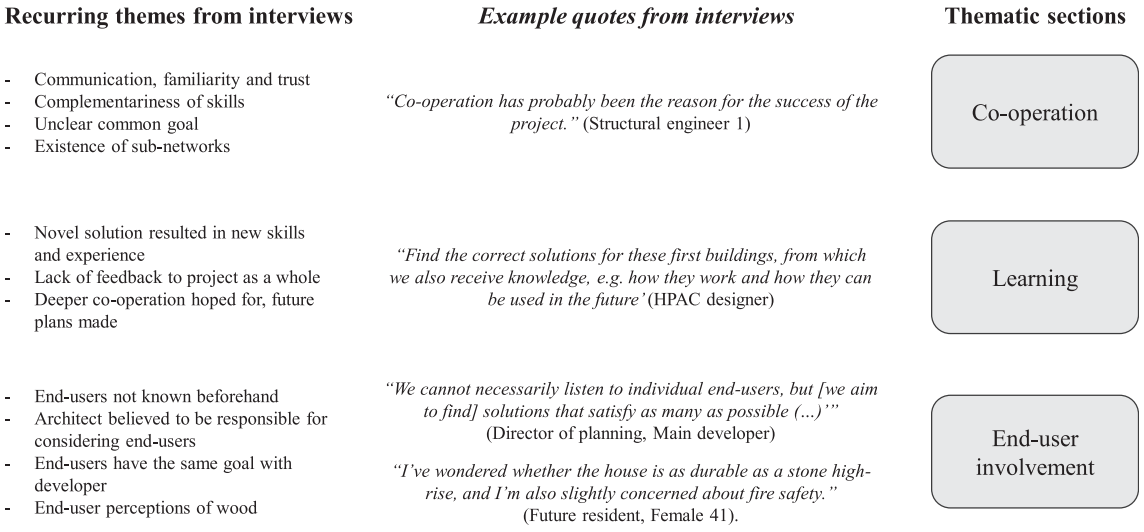

Fig. 2. Examples showcasing the data analysis used in the study.

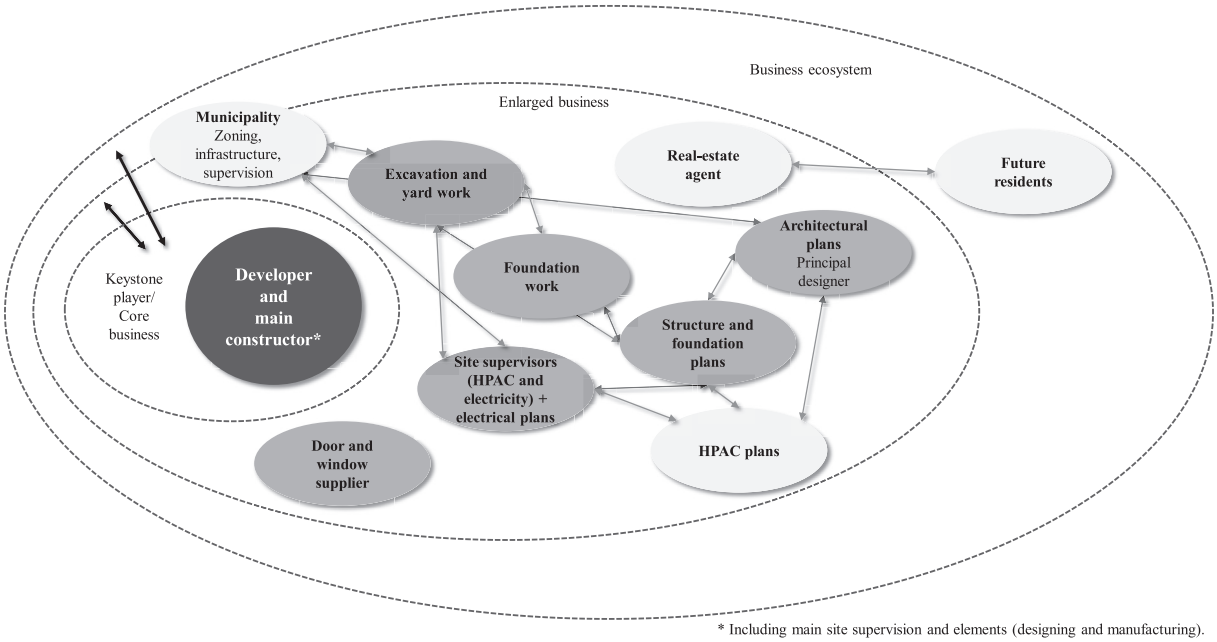

Fig. 3. A static illustration of the business ecosystem during the design and construction phases in the WMC case project. Darker ovals represent actors with previous/ongoing activities with the developer, while lighter ovals represent occasional partners. The developer communicates with all actors within the ecosystem (dark arrows), and communication additionally occurs between the actors (lighter arrows).

The developer needed *specialized actors, each possessing complementary capabilities,* for the designing and construction phases. As described by the DoP, they formed the network partly by using invitations for tenders along with co-operation contracts. Complementary knowledge together with merits gained from previously working with the developer were of high importance when choosing the partner companies — contrary to traditional procurement methods in the construction industry (Blayse and Manley, 2004).

Project co-operation was reinforced with trust and familiarity, which formed between the actors through their common history and was nurtured by continuity (see also de Meyer and Williamson, 2020), as the interviewees described. For example, working with familiar actors lessens the formality of communications, as questions can be asked quickly via e-mail or phone. The co-operation and history of building together seem to have strengthened the network and has led to a group of actors revolving around the main developer:

> We have been running around the same sites and all across Finland. Particularly companies responsible for foundations, and HPAC- and electricity-related site work are involved in the activities of the main developer just like we are, which is why we tour Finland. — Excavation Company —

Actors with previous experience working with the main developer were more likely to be familiar with wood as a construction material. Occasional partners, such as sub-contractors, were more often less familiar with wood as a construction material, and they regarded the case project as a good opportunity for learning. On the other hand, actors unaffected by the material choice, such as the company excavating the foundations, considered the project nothing out of the ordinary. However, most actors were affected by the main construction material, if not directly, then at least indirectly due to the shorter turnaround time caused by avoiding drying times that are typical when using concrete.

Although co-operation plays a focal role in the governance of a business ecosystem, the interviewees did not recognize all players of the ecosystem as equally important, confirming findings from Toppinen et al. (2019). Both the regional authority (local municipality representative) and end-users were considered rather distinct actors from the companies' viewpoints, which in the longer run may weaken ecosystem activities such as knowledge transfer and accumulation.

The *local municipality's* role occurred already at the beginning of the project in the form of zoning, along with providing construction permits and site-related infrastructure. The zoning architect of the municipality believed their role in the construction projects to be somewhat greater than in municipalities in general, because in this case they engaged in a steering role already from the beginning of the project. Project companies, however, did not recognize the steering role of the municipality. Instead, following the regulations set by the municipality appeared to be routine to the actors.

The project actors struggled to recognize the *end-users* as part of the network until the very final phase, although the importance of end-users as a part of the business ecosystem is emphasized in related literature (Eriksson et al., 2015). Interviews conducted during project implementation showed that end-users were considered a more general stakeholder group. The developer emphasized that while they were unable to consider all individual preferences, they aimed to find solutions that suit the end-users on a more general level:

> (…) the end-user is the one who pays, so of course the apartments must be good enough for them and their voices need to be heard. (…) We cannot necessarily listen to individual end-users, but [we aim to find] solutions that satisfy as many as possible and to provide alternatives from which the end-user can find the most suitable one. — Director of planning, R&D and IT, Main developer —

While the main developer thus recognized the importance of considering the end-users, the company, along with most of the

other project actors, relied on the expertise of the *architect* to design functional apartments that fit the needs of most homebuyers.

The interviews indicate that the project actors appreciated co-operating with trustworthy, skilled partners, which was enabled by the keystone company, who assembled the project team mainly based on previous experiences. The actors specializing in the studied project stages, namely design and construction, seemed to be located closer to the keystone, leaving the municipality and future residents at the outskirts of the ecosystem.

4.2. Learning to build with a novel wooden material

As Williamson and de Meyer (2012) have argued, one success factor of the business ecosystem and its co-evolution is the ability to promote mutual learning, resource sharing, and knowledge transfer among partners. The novel use of wood in the project stressed the need of these aspects more than earlier projects. The keystone player (main developer) was familiar with working with wooden materials and promoted transferring this knowledge to other actors and facilitating their collective value creation and collaborative learning process (Pulkka et al., 2016). The actors together attempted to find the best and easiest way of working with the elements:

> We and Company J (company responsible for electrical and plumbing work) have considered what would facilitate working at the site – mostly from the HPAC viewpoint – regarding the base and intermediate floor solutions. To make the process smoother for [Company J], and not be so … Well, it is laborious. – Site supervisor, Main developer –

Working as a team and communicating efficiently were emphasized as essential aspects for the construction network to function properly (see also e.g. Häkkinen and Belloni, 2011). The technical accuracy of the plans and schedules is especially essential for project success, as described by the structural designer:

> Co-operation has probably been the reason for the project being successful. Not just drawing out plans by ourselves, but specifically being in contact with the other actors. Checking [the plans] together, to avoid surprises, matching the plans with each other. This must be one of the most significant [factors]. – Structural engineer 1 –

From the perspective of business ecosystem governance, the newly adopted role of the element manufacturing company forced their staff to work outside of their comfort zone, resulting in leadership challenges. This was noticeable for example when interviewees were asked about the project's main aim. Instead of mentioning the aim determined by the main developer (keystone player) —i.e. testing the new wooden elements in an efficient manner —*the actors admitted to not knowing the aim* or stated it to plainly be 'constructing a building' (Structural engineer 2). The main developer, who was accustomed and experienced in working with wooden materials, emphasized the building's high technical quality and cost-effectiveness. Other partners focused more on constructing the building itself. This communication shortage appeared when the project suffered to some extent from an excessively tight schedule, determined by the main developer. A kick-off meeting at the beginning of the project was described as a solid base for project initiation, but it did not include all project actors. Consequently, the knowledge of the participating companies was usually limited to the companies the interviewee had worked with—a type of a sub-network (see Fig. 3). Additionally, *mutual learning was somewhat hindered by the formation of sub-groups* between the designers and actors at the site, which appears to be typical in construction projects in general:

> Feedback from the construction site and the builders would be nice. For example, how the plans worked out and so on. (…) It is like in the army: if everything is going fine, there is no [feedback], but if something goes wrong, you are remembered. This is generally the way this job works. – Structural engineer 2 –

According to Gann and Salter (2000) and Mokhlesian and Holmén (2012), feedback processes are critical for knowledge accumulation. Certain interviewees regarded this lack of feedback as an undesirable situation preventing learning, while certain actors were indifferent about what occured in the project as a whole. This could also be an example of *self-interested thinking*, which was also visible in the project: 'If there is a need, then of course we will discuss it with the other companies. But [renewing old working habits] is mostly self-improvement.' (Company responsible for foundation work). On the other hand, certain interviewees would have been interested in hearing how the project had advanced after their tasks were completed. However, *the entire project crew did not receive any communications concerning the overall progress of the project.* Despite these above-mentioned limitations, the interviews revealed that a governance structure existed in the business ecosystem, with control over membership and tasks (Thomas and Autio, 2014), providing a solid basis for operational and functional efficiency.

As suggested by Aarikka-Stenroos and Ritala (2017), the business ecosystem concept emphasizes co-evolution, along with increased interdependency and capabilities of all actors. Most of the companies continued their co-operation with the main developer after this project ended. The two companies working with excavation and foundations mentioned that they had already considered deepening the co-operation between their companies by providing a joint contract where the client sees their actions as unified. Thus, ecosystem thinking ties up companies into *continuous co-evolvement*, which creates smaller ecosystem niches within the project. Yet, as the developer noted, maintaining project co-operation may be difficult due to tight schedules and each company having *several overlapping projects*. If companies deepen their interactions by forming two- or three-company sub-networks within the ecosystem, the lead firm's task of coordinating communication and co-operation between the actors may become easier.

Co-evolution and mutual learning between the ecosystem actors existed despite the project's one-of-a-kind nature (Blayse and Manley, 2004), yet communication was somewhat lacking, especially concerning shared goal and feedback mechanisms. Interestingly, none of the actors highlighted the sustainability aspects of WMC, even though experts believe that the increasing interest towards sustainability generates a major market opportunity for wood-building industries (Toppinen et al., 2018).

4.3. End-user involvement in the wood-based construction business

According to Jensen and Gram-Hansen (2008) and Eriksson et al. (2015), end-user involvement has been seen to enhance a sustainability transition in the building sector. However, company representatives struggled to identify end-users as collaborators in the ecosystem. For example, they believed that including end-users at an earlier stage, i.e. during the design process, would be neither feasible nor sensible, as indicated in a comment from an estate agent:

> No no. [The developer] doesn't know whose going to live there. They would have to organize a general hullabaloo [marketing event]: 'Come and see our plans! Would you like to buy one of these [apartments]?' Then [the customers] will say, 'I want such and such (changes done)!' and won't end up buying [the apartment] anyway. – Estate agent –

Future residents became involved when the apartments were otherwise ready, but were still so-called 'empty shells' that the future residents could personalize by selecting from a provided set of materials, finishes, and appliances. This is a common practise in Finland when buying an apartment from a nearly completed building (see Autio and Autio, 2013). The estate agent, responsible for selling the apartments, conducted most of the communication with the end-users during the project, yet the project relied on the architect's ability to provide viable solutions for 'good living'. When choosing an apartment from the case building, future residents were attracted by newness, location, affordable pricing, and an efficient layout (Viholainen et al., 2020; see also Gold and Rubik, 2009). While purchasing a brand new apartment, they also hoped for a high-quality building. These properties coincided with the developer's aims:

> Yes, [the apartments] were sold quickly, and probably partly because the pricing is fairly moderate. The location (…) definitely contributes and the floorplan has been thought through, so there is no wasted space (…). The aims were to make high-quality homes while keeping costs as low as possible. – Site supervisor, Main developer –

End-users appeared to share the same goal as the business actors — high-quality living. As a 58-year-old resident argues: "if it [wood] has some better qualities than concrete, then I could pay [more than for concrete]". This could be used as a good starting point for deepening the discussion with end-users and also accumulating end-user -related knowledge.

Similarly to the interviewed construction professionals, the future residents did not underline wooden materials as an important quality aspect. Wood material is mainly a pleasant bonus feature for future residents, who described it with words such as 'clean', 'natural', 'healthy', 'renewable', and 'a domestic material', but concerns related to the wood material were also expressed, for example fire safety (see also e.g. Larasatie et al., 2018; Viholainen et al., 2020). Therefore, while the wooden material was reflected positively by homebuyers, it also created a certain amount of confusion. Further discussion with the future residents also revealed that most of their views concerning wood — especially adverse opinions — were mainly images based on second-hand information.

> I would probably figure out why it is more expensive, I would need some expert view, I don't understand these [questions] myself (…). If someone who understands and is not biased would say that it is worth buying, (…), then yes [I could pay more for wood than for concrete]. – Future resident, male, 32–

End-users also have a need for more first-hand knowledge concerning wooden buildings, as also argued e.g. by Lähtinen et al. (2019). The interviewed end-users implied they would have appreciated being able to communicate with the project management, to influence the design process, and being more up-to-date on the progress of the construction project.

The deeper involvement of end-users may enhance their commitment in their housing decisions throughout the building project (Eriksson et al., 2015), while project actors may receive valuable information regarding the preferences of elusive end-users. The interaction and aims between end-user and companies (i.e. shared logic) becomes more visible with growing trust and awareness of mutual interests (Thomas and Autio, 2014), which in this case project was framed as "high-quality (wooden) living". Overall, it seems that wood as a sustainability-driven material can provide higher customer value (Lessing and Brege, 2018), but this needs to be communicated to the end-users.

4.4. Enablers and barriers of collaboration in the wooden multi-storey business ecosystem

The key enablers and barriers towards collaboration and closer end-user involvement in the WMC ecosystem case are summarized in Table 3 and are organized under the three elements of business ecosystem: the network of participants, governance system, and shared logic (Pulkka et al., 2016).

Regarding the *network of participants*, our analysis shows that the strength of the business ecosystem lies in each member complementing the project with unique skills and knowledge that are shared and combined between project participants — especially when working on novel ideas. While continuity fosters knowledge accumulation, the urgency from other ongoing projects may force project developers to seek the expertise of unfamiliar companies, thus losing some of the previously acquired knowledge. A key

Table 3
Enablers and barriers distinctive for the wooden multi-storey case in the construction business ecosystem.

Business ecosystem element	Enablers	Barriers
Network of participants	- Complementary capabilities of a novel wooden material - Co-evolution: from a project-based approach towards more longstanding co-operation and mutual learning in new sustainability-driven projects - A sustainability-driven material as a learning case for stakeholders: requires unique skills and knowledge	- Urgency and lack of time due to several overlapping projects - End-users not perceived as active actors, their views and concerns of the material choices are neglected - Companies not valuing all participants of an ecosystem equally, such as municipal representatives and end-users
Governance system	- Keystone player orchestrates BE (choosing partners) and shares information on wooden materials to other core companies - Keystone player coordinates and enables smooth communication practices in a novel project set up	- Limited feedback of how WMC succeeds, lack of communication within sub-groups - Players reluctant to share information, emphasizing self-interests and business-as-usual ways to build - Only statutory communication with end-users, follow-up missing
Shared logic	- Trust between business actors and their accumulating familiarity with novel wooden building techniques - Similar aim to produce high-quality housing	- Limited mutual awareness and lack of clarity concerning project goals; keystone player "innovates with wood material", while others are "just building a house" - Lack of shared understanding on sustainability aspects of material between business and end-users

limitation of a collaborative business ecosystem approach appears to be that end-users are not recognized as legitimate members of the ecosystem, especially in the early stages of the design processes. Business actors may even perceive increased end-user involvement as a source of increased complexity, which threatens project profitability.

Second, *the governance system* refers to the organization of information flow within the ecosystem. In our case, a shared vision of the project's experimental aspects was not communicated sufficiently by the project leader to the other actors, and the sustainability aspects of WMC were not discussed by the ecosystem members. The keystone player's enabling role in promoting learning and encouraging innovations is recognized among the ecosystem actors. Similar to Aksenova et al. (2019), the supply-side keystone player had a clear orchestrating role over the networkof participants. Nevertheless, information sharing and communication practices across participants appeared too limited due to tight project scheduling and lacking leadership skills of the keystone in its new role as a project leader. This seemed to hinder collaboration and engagement with future residents.

Third, a *shared logic* between the ecosystem participants associates with a level of trust and familiarity. That is, working with familiar and trustworthy actors creates an open, informal atmosphere, where novel ideas and solutions may be more easily shared. Instead, newer business participants in the studied case appeared to be unaware of the novel aspects of the project, such as the sustainability aspects of wood material and its importance in the sustainability transition. To make the ecological sustainability of wooden material a common goal of the network, it should also be integrated into the common objectives (part of the network considered "just building a house" to be the objective). Thus, sharing project aims with network actors was not fully successful in terms of sustainability, yet the keystone player along with other players was able to build customer-friendly apartments using a novel low-carbon material.

5. Discussion

5.1. Collaboration, knowledge transfer, and end-user involvement in building new sustainable wooden solutions

By using the *business ecosystem* approach as a tool for construction business renewal, our study contributes to the theoretical discussion on promoting the sustainability of the construction industry (e.g. Berardi, 2012; Matinaro and Liu, 2017; Martek et al., 2019a; 2019b), as well as to the business ecosystem literature (e.g. Pulkka et al., 2016; Aksenova et al., 2019), especially from the viewpoint of knowledge sharing (e.g. Wulf and Butel, 2017) and end-user involvement (e.g. Joo and Shin, 2018).

Further reflection should be given to the connections of the study findings to the three core elements from business ecosystem literature (Thomas and Autio, 2014; Pulkka et al., 2016), i.e. *shared logic* and *the governance system* affecting value creation via a *network of participants*. Our results indicate that longstanding cooperation, solid coordination, and efficient communication facilitate knowledge transfer and mutual learning of WMC solutions. The keystone player has an important role in promoting mutual learning (Williamson and de Meyer, 2012) and in maintaining openness towards innovations (Paquin et al., 2013). Informal (tacit knowledge) communication procedures appear beneficial for substituting formal task coordination (plans, schedules), also pointed out by Pulkka et al. (2016). Similarly, our results show that familiarity between project participants creates trust, leading to better understanding of the working habits of other participants, thus decreasing the need for formal task coordination (Pulkka et al., 2016). Further, the results indicated how the project-based business ecosystem evolves over various phases as presented in Fig. 4, i.e. participant involvement differs in the living and use phase when compared to the design and construction pahse, and each phase can have its specific individual goals (see also Heikkilä and Kuivaniemi, 2012; Lappi et al., 2017).

The key message from a managerial perspective is that the developer and main contractor need to adopt a strong leadership role over the business ecosystem, and that feedback is needed for the ecosystem to function efficiently and for learning to take place. Interestingly, the main contractor came from the supply side, which is perhaps a phenomenon specific to this line of business compared to the conventional construction business (see also Pulkka et al., 2016; Aksenova et al., 2019).

Does the importance of co-operation, communication, and sharing a common goal in the ecosystem also lead to end-user involvement? According to our results, the capabilities of the end-users remain largely underutilized, confirming the results by Byggeballe and Ingemansson (2014). Future residents were only recognized as home purchasers towards the final phase of the construction project and not as legitimate members of the design and construction phase ecosystem. The results indicate that the possibilities of future residents in influencing their future homes were restricted to traditional choices of interior materials and minor change requests, which is symptomatic of mass customization. This was also identified in Toppinen et al. (2019), focusing on three WMC projects with varying depth and duration in their collaboration.

Managerial recommendations emerging from this finding are: i) the orchestration of an ecosystem calls for active monitoring of, for example, changes in consumer values and appreciations of wood and ii) acknowledging end-user needs would be important throughout the project life span and beyond. However, iii) successful end-user participation calls for various means utilized during the different phases of a project and after completion (when the building is being lived in) (see e.g. Pemsel et al., 2010). Thus, it may seem laborious and costly to increase end-user inclusion. Nevertheless, we encourage firms to begin user inclusion by capitalizing on their own cumulative experiences across projects. By extending into the use phase (see Lappi et al. (2017) for business ecosystem formation by an anchoring actor), user-driven innovations would support project-to-project learning and strengthen ecosystem development. However, better understanding is needed to identify how to facilitate end-user inclusion early enough, and in a way that would not increase complexity or decrease cost competitiveness.

Based on our results, the business ecosystem approach that supports the emergence of sustainability-driven logic when building with wood is enabled via inter-organizational co-operation and stakeholder involvement. However, several barriers also seem to be in place. The enablers and barriers of collaboration in the WMC business ecosystem that we indentified (Table 3) may be useful for other sustainability-driven innovations among project organizations for enhancing knowledge accumulation and end-user engagement among project actors. This is in line with Martek et al. (2019a, 2019b), who suggest that a dysfunctional ecosystem may hinder the uptake of more sustainable building materials. For example, in the case of WMCs, alleviating the shortage of skills and knowledge accumulation only from the niche innovation level may ultimately lead to increased demand and mainstreaming and may hence promote a more fundamental sustainability transition within the sector (Geels, 2002; Lazarevic et al., 2020).

According to Lazarevic et al. (2020), the lack of a shared vision for WMC is a key factor slowing down the take-off of these new,

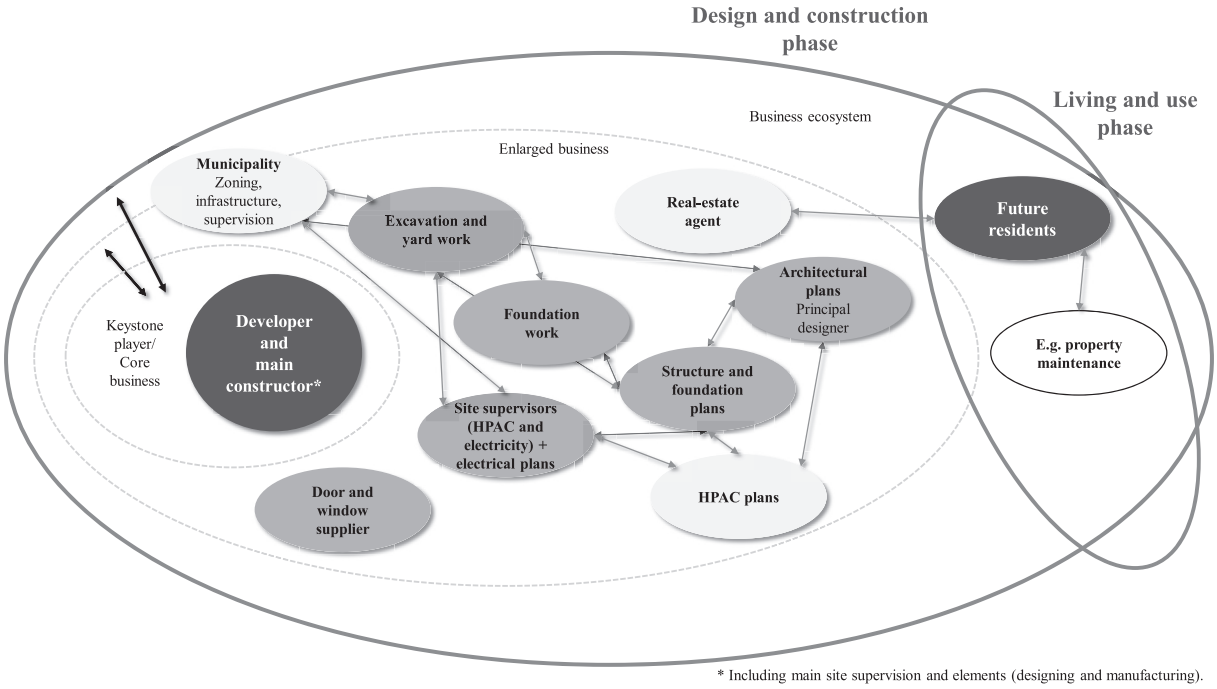

Fig. 4. Illustration of the business ecosystem change from design and construction phase into living and use phase in the WMC case project.

more sustainable building technologies. Our study also confirmed this challenge, as the project members expressed only limited awareness of innovative sustainability aspects being present. Futhermore, the sustainability aspects were not actively shared with end-users, who also did not stress the sustainability of the wood material choices. However, the residents view wood as a clean, natural, healthy, and renewable material (e.g. Viholainen et al., 2020), indicating that the business network is able to create value by using wooden materials. Nevertheless, buying an apartment is still often the largest household investment, which possibly overrides any ecological concerns. Adopting a more dynamic perspective (talking to stakeholders, thinking about the problem, testing the product/service) is crucial for the emergence of actual sustainable value creation of innovations (Baldassarre et al., 2017). From a managerial perspective, one key message is that for a business to thrive, creating a shared sustainability-driven logic is an essential task.

Pulkka et al. (2016) demonstrated the applicability of the business ecosystem concept in the construction field, yet we also recognized challenges. First, it is noteworthy that the business ecosystem approach originates from the information and communication business context, where users have the capacity to act in content production (e.g. Joo and Shin, 2018), whereas planning and building in the construction industry require, for example, expertise in architecture and structural engineering, machinery, and a financial base that are not easily available for users. In addition, the ecosystem approach does not account well for the time span or capital intensity, which are distinctive to the construction business. The final product is a house that will exist for decades, with residents bearing maintenance costs once the design and construction phase actors in the ecosystem have already moved on to new projects. After the building is finalized, the residents will become the ecosystem keystone players, as they will build a new ecosystem around house maintenance (energy supplier, maintenance company selection, waste management, painting of timber parts etc.). Thus, the ecosystem evolves within this new set of stakeholders (see Fig. 4). While recent business ecosystem studies in the field of construction (e.g. Pulkka et al., 2016) have focused on value creation, our study has deepened the understanding of collaborative learning and end-user consideration by shifting the focus to new low-carbon construction solutions. According to Toppinen et al. (2019), learning to work with wood material in multi-storey applications is likely the greatest outcome of emerging WMC business ecosystems in addition to building familiarity with the new partner networks. However, a cultural change in the building sector is needed to overcome the culture of favouring simple transactional, sub-contracting -type relationships, as also advocated recently by Gosselin et al. (2018).

Nationally and internationally, there are strong policy drivers related to climate change mitigation via lower carbon construction, and there is a need to identify and upscale to more environmentally, economically, and socially sustainable building solutions. To promote the diffusion of WMC in the urban construction market, providing financial 'carrots' to incentivize the use of WMC technologies seems pertinent regarding capacity building and gaining more technical experience beyond pilot projects, as also advocated by Lazarevic et al. (2020). There is also a need to break through sectoral silos (e.g. between construction and wood manufacturing actors), as also suggested by previous studies on regional forest sector innovation systems (Weiss et al., 2017).

5.2. Limitations of the study and future research needs

Our study has several limitations. We examined the operation of a business ecosystem in the form of one residential wood-frame building construction project. The obtained results are therefore not generalizable as such. However, the results increase understanding of the applicability of the business ecosystem approach in the WMC setting, where the aim is to learn how to build sustainability-driven homes for people. The data consist of interviews during zoning, designing, and site operations. The tasks of certain interviewed actors had been performed several months previously, which decreased the depth of the interview discussions and made the study case project blend in with other projects they

had worked on since. Following the formation and functioning of the project right from the beginning and conducting interviews when the tasks are topical could have provided more in-depth information concerning the studied case project. Despite the data being saturated regarding the studied aspects, strict replication of the findings would be a challenge, as always when using personal interviews in a project-based setting.

Moreover, while analytical dimensions of Thomas and Autio's (2014) framework, namely the network of participants (i.e. specialization, complementariness, and co-evolution), governance (i.e. authority structure, membership control, and task coordination), and shared logic (i.e. legitimacy, trust, and mutual awareness), are elementary for understanding the business ecosystem concept and how to co-create value, they could not be fully covered during our data collection stage. As the analysis is limited from the perspective that it does not cover any sub-dimensions of the Thomas and Autio (2014) model (see above for main and sub-dimensions), a follow-up study would be recommended. Studying business ecosystem development and the establishment of co-operation and knowledge accumulation processes over a longer time (see also Heikkilä and Kivimäki, 2012) would also be interesting future research for understanding whether a WMC business (as an emerging alternative to mainstream concrete-based construction) is actually able to overcome some of the challenges related to the project-based nature of the whole construction industry (Gann and Salter, 2000; Hemström et al., 2017). A logical continuum would be conducting similar research for more complex building projects, such as higher-rise wooden building, and also in other contexts (see also Gosselin et al., 2018).

There is one critical deficit in the business ecosystem approach itself that also became evident during our study: the actors' limited view of sustainability. Thus, to accelerate a sustainability transition, business ecosystem value creation should stress ecological and social values next to monetary values. While the current business ecosystem literature focuses on short-term business success rather than longer-term resilience, the wooden construction business can be seen as a step towards that transition by bringing sustainability to the centre of value creation.

Further research of business ecosystem actors in the conventional construction industry may be useful for discovering the benefits of inter-company knowledge accumulation and co-learning from the perspective of sustainability and the role that material choices play in it. Especially knowledge accumulation practices and the deeper involvement of end-users could be studied more explicitly, for example by analysing building projects that test innovative methods of end-user integration or by comparing projects that involve end-users from the beginning with projects that involve end-users only at later stages of construction.

Future research must also address (potential) power asymmetries that exist between other stakeholders to overcome business ecosystem dysfunctionality. By doing this, we could see what benefits may be gained from early involvement that would also be demonstrated in perceived end-user satisfaction, leading to better word-of-mouth. Last but not least, future research is needed on sustainability-related knowledge as a driver of mutual learning and co-evolvement to enable successful sustainability transitions, especially in the short-term project-based settings such as those demonstrated in this study. For example, a follow-up research of the buildings while they are inhabited by the residents would provide valuable information on the endurance of novel materials in use and on the actual sustainability of the buildings related to maintenance and energy consumption.

6. Conclusions

With a global need to reduce building sector emissions to be compatible with the "1.5-degree world", conventional construction industry has to change, and mainstreaming is needed for new low-carbon material -based solutions such as multi-storey wooden construction. In light of this study, knowledge accumulation, learning processes, and end-user inclusion (and keystone playerism in the late phase of the ecosystem) were found to be crucial elements for WMC business ecosystems to develop shared sustainability-driven logic alongside profitable business and creating value for consumers. However, the limited ecosystem-level awareness regarding the benefits of using renewable construction materials slowed down the sustainability transition of the construction industry. Our in-depth case study identified key barriers of deeper collaboration and business ecosystem development towards sustainability, such as weak end-user involvement and the lack of clarity in the shared goals between various actors. Moreover, we also recognized enabling factors such as smooth communication and building trust among new ecosystem partners. In conclusion, our analysis of the business ecosystem concept revealed that the current networks do not utilize their full potential, but i) the keystone players should develop their leadership skills, especially regarding the communication of common goals and feedback, ii) end-user involvement should be deepened by shifting focus from singular projects to continuous communication, and iii) a more inclusive approach to new business ecosystem participants is needed, spanning from the planning and building stages to the living and use phase.

CRediT authorship contribution statement

Eliisa Kylkilahti: Viholainen: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - review & editing, Visualization. **Minna Autio:** Conceptualization, Methodology, Validation, Writing - review & editing. **Juho Pöyhönen:** Conceptualization, Methodology, Validation, Writing - review & editing. **Anne Toppinen:** Formal analysis, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Financial support from the Academy of Finland (Grants 307480, 335241), Tekes 642/31/2016, and Metsämiesten Säätiö Foundation aregratefully acknowledged. We are grateful for constructive feedback from the six reviewers of the journal that helped to improve the paper.

Appendix. Themes and questions of the semi-structured interviews

Project actor interviews

Theme 1: Formation of the business ecosystem and its operation.

- What are the role and tasks of the company you represent for project XYZ?
- How did the company you represent become involved in the project?
  - How were the other companies involved in the project chosen?
- What are goals of the project? How have they been defined?

Theme 2: Co-operation with the project companies?

- What companies have been important/less important co-operation partners or customers for the company you represent in this project? What kind of co-operation has occurred?
  - How is co-operation administered in the project? (informal/contracts?)
  - How do you see the role of city ABC and other authorities in this project?
- What kind of different and complementary know-how do you think other companies bring to the project?
- What obstacles exist for deepening the co-operation? What about opportunities?

Theme 3: Benefits of co-operation.

- What benefits has the project and project-related co-operation created for the company you represent?
  - What kind of benefits have been created for other companies involved in the project and for residents during the project?
- What are essential matters for project success and for the smoothness of co-operation?
  - Did the project advance smoothly in your opinion? What kind of obstacles or hindrances did you face?

Theme 4: Consideration of the residents.

- How have the needs, wishes, and opinions of the residents been taken into account in the project?
- How has the data concerning resident needs and wishes been acquired and how has it been used?
  - How has this data been shared from company to company within the project?

Theme 5: New modes of operation.

- What kind of new modes of operation, solutions, products, or ideas came into existence for this project or during the project? How did they come into existence?
  - How were they communicated to other members of the project and how was their introduction promoted?
- How will these new modes of operation, solutions, etc. be utilized in futureprojects?
  - How have the experiences of earlier projects been utilized in other projects?

Future resident interviews

Background information.

Theme 1: Previous homes and issues valued in housing.

Theme 2: Choosing the apartment and making the purchase decision.

Theme 3: Characteristics of the apartment and the neighbourhood.

Theme 4: Perceptions of wooden materials.

- What images and perceptions arise when you think about wood? Are they positive or negative?

Theme 5: Inclusion of resident needs and expectations.

- Were you able to express your needs and wishes during the planning/construction process? How? Would you be willing to pay extra to be able to tailor something according to your needs?
- What do you expect from your new apartment (incl. the interior, exterior, neighbourhood, yard)?
- How/where do you expect to see wood within the apartment/in the building overall? Why?
- Where would you not like to see/have wood? Why?

Theme 6: Consumer profile.

References

Aarikka-Stenroos, L., Ritala, P., 2017. Network management in the era of ecosystems: systematic review and management framework. Ind. Market. Manag. 67, 23–36. https://doi.org/10.1016/j.indmarman.2017.08.010.

Adner, R., Kapoor, R., 2010. Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations. Strat. Manag. J. 31 (3), 306–333. https://doi.org/10.1002/smj.821.

Aksenova, G., Kiviniemi, A., Kocaturk, T., Lejeune, A., 2019. From Finnish AEC knowledge ecosystem to business ecosystem: lessons learned from the national deployment of BIM. Construct. Manag. Econ. 37 (6), 317–335. https://doi.org/10.1080/01446193.2018.1481985.

Autio, M., Autio, J., 2013. Consumers purchasing new homes – trust and taste building through e-service and competence in the housing market. Int. J. Serv. Econ. Manag. 5 (4), 328–340. https://doi.org/10.1504/IJSEM.2013.059574.

Baldassarre, B., Calabretta, G., Bocken, N.M.P., Jaskiewicz, T., 2017. Bridging sustainable business model innovation and user-driven innovation: a process for sustainable value proposition design. J. Clean. Prod. 147, 175–186.

Berardi, U., 2012. Sustainability assessment in the construction sector: rating systems and rated buildings. Sustain. Dev. 20 (6), 411–424.

Blayse, A.M., Manley, K., 2004. Key influences on construction innovation. Construct. Innovat. 4 (3), 143–154. https://doi.org/10.1108/14714170410815060.

Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qual. Res. Psychol. 3 (2), 77–101.

Bygballe, L.E., Ingemansson, M., 2014. The logic of innovation in construction. Ind. Market. Manag. 43 (3), 512–524. https://doi.org/10.1016/j.indmarman.2013.12.019.

Clarysse, B., Wright, M., Bruneel, J., Mahajan, A., 2014. Creating value in ecosystems: crossing the chasm between knowledge and business ecosystems. Res. Pol. 43 (7), 1164–1176. https://doi.org/10.1016/j.respol.2014.04.014.

Dixit, M.K., Fernández-Solís, J.L., Lavy, S., Culp, C.H., 2010. Identification of parameters for embodied energy measurement: a literature review. Energy Build. 42 (8), 1238–1247.

Edwards, R., Holland, J., 2013. What Is Qualitative Interviewing? Bloomsbury, London, UK, p. 144. ISBN 10:9781780938523.

Eriksson, J., Glad, W., Johansson, M., 2015. User involvement in Swedish residential building projects: a stakeholder perspective. J. Hous. Built Environ. 30 (2), 313–329. https://doi.org/10.1007/s10901-014-9412-7.

Eriksson, K., Wikström, K., Hellström, M., Levitt, R.E., 2019. Projects in the business ecosystems: the case of short sea shipping and logistics. Proj. Manag. J. 50 (2), 195–209. https://doi.org/10.1177/8756972818820191.

Franzini, F., Toivonen, R., Toppinen, A., 2018. Why not wood? Benefits and barriers of wood as a multistory construction material: perceptions of municipal civil servants from Finland. Buildings 8 (11), 159. https://doi.org/10.3390/buildings8110159.

Gann, D.M., Salter, A.J., 2000. Innovation in project-based, service-enhanced firms: the construction of complex products and systems. Res. Pol. 29 (7–8), 955–972. https://doi.org/10.1016/S0048-7333(00)00114-1.

Geels, F.W., 2002. Technological transitions as evolutionary configuration processes: a multi-level perspective and a case-study. Res. Pol. 31 (8/9), 1257–1274.

Gold, S., Rubik, F., 2009. Consumer attitudes towards timber as a construction material and towards timber frame houses - selected findings of a representative survey among the German population. J. Clean. Prod. 17 (2), 303–309. https://doi.org/10.1016/j.jclepro.2008.07.001.

Gosselin, A., Blanchet, P., Lehoux, N., Cimon, Y., 2017. Main motivations and barriers for using wood in multi-story and non-residential construction projects. BioResouces 12 (1), 546–570.

Gosselin, A., Blanchet, P., Lehoux, N., Cim, Y., 2018. Collaboration enables innovative timber structure adoption in construction. Buildings 8, 183. http://doi:10.3390/buildings8120183.

Gupta, R., Mejia, C., Kajikawa, Y., 2019. Business, innovation and digital ecosystems landscape survey and knowledge cross sharing. Technol. Forecast. Soc. Change

147, 100–109. https://doi.org/10.1016/j.techfore.2019.07.004.
Hemström, K., Gustavsson, L., Mahapatra, K., 2017. The sociotechnical regime and Swedish contractor perceptions of structural frames. Construct. Manag. Econ. 35 (4), 184–195. https://doi.org/10.1080/01446193.2016.1245428.
Hildebrandt, J., Hagermann, N., Thrän, D., 2017. The contribution of wood-based construction materials for leveraging a low carbon building sector in Europe. Sustainable Cities and Society 34, 405–428. https://doi.org/10.1016/j.scs.2017.06.013.
Heikkilä, M., Kuivaniemi, L., 2012. Ecosystem under construction: an action research study on entrepreneurship in a business ecosystem. Technology Innovation Management Review. http://timreview.ca/article/564.
Huang, L., Krigsvoll, G., Johansen, F., Liu, Y., Zhang, X., 2018. Carbon emission of global construction sector. Renew. Sustain. Energy Rev. 81, 1906–1916.
Hurmekoski, E., Jonsson, R., Nord, T., 2015. Context, drivers, and future potential for wood-frame multi-story construction in Europe. Technol. Forecast. Soc. Change 99, 181–196. https://doi.org/10.1016/j.techfore.2015.07.002.
Hurmekoski, E., Pykäläinen, J., Hetemäki, L., 2018. Long-term targets for green building: explorative Delphi backcasting study on wood-frame multi-story construction in Finland. J. Clean. Prod. 172, 3644–3654. https://doi.org/10.1016/j.jclepro.2017.08.031.
Hsieh, Y.-C., Lin, K.-Y., Rong, K., 2017. Governing a sustainable business ecosystem in Taiwan's circular economy: the story of spring pool glass. Sustainability 9 (6), 1068. https://doi.org/10.3390/su9061068.
Håkansson, H., Ingemansson, M., 2013. Industrial renewal within the construction network. Construct. Manag. Econ. 31 (1), 40–61. https://doi.org/10.1080/01446193.2012.737470.
Häkkinen, T., Belloni, K., 2011. Barriers and drivers for sustainable building. Build. Res. Inf. 39 (3), 239–255. https://doi.org/10.1080/09613218.2011.56194810.1080/09613218.2011.561948.
Høibø, O., Hansen, E., Nybakk, E., 2015. Building material preferences with a focus on wood in urban housing: durability and environmental impacts. Can. J. For. Res. 45 (11), 1617–1627.
Høibø, O., Hansen, E., Nybakk, E., Nygaard, M., 2018. Preferences for urban building materials: does building culture background matter? Forests 9 (8), 504.
Iansiti, M., Levien, R., 2004. Keystones and Dominators: Framing Operating and Technology Strategy in a Business Ecosystem, 03-061. Harvard Business School, Boston, pp. 1–82. Retrieved from. https://www.profligategrace.com/documents/Grant/Iansiti_Keystones_and_Dominators.pdf, 19.8.2020.
IPCC, 2018. Summary for policymakers. In: Masson-Delmotte, V., Zhai, P., Pörtner, H.O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M., Waterfield, T. (Eds.), Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. World Meteorological Organization, Geneva, Switzerland, p. 32.
Irvine, A., Drew, P., Sainsbury, R., 2013. 'Am I not answering your questions properly?' Clarification, adequacy and responsiveness in semi-structured telephone and face-to-face interviews. Qual. Res. 13 (1), 87–106.
Jensen, J.O., Gram-Hanssen, K., 2008. Ecological modernization of sustainable buildings: a Danish perspective. Build. Res. Inf. 36 (2), 146–158. https://doi.org/10.1080/09613210701642337.
Joo, J., Shin, M.M., 2018. Building sustainable business ecosystems through customer participation: a lesson from South Korean cases. Asia Pac. Manag. Rev. 23 (1), 1–11. https://doi.org/10.1016/j.apmrv.2017.01.001.
Koenig, G., 2012. Le concept d'écosystème d'affaires revisité. M@n@gement 15 (2), 209–224. https://doi.org/10.3917/mana.152.0209.
Lappi, T., Lee, T., Aaltonen, K., 2017. Assessing the health of a business ecosystem : the contribution of the anchoring actor in the formation phase. International Journal of Management, Knowledge and Learning 6 (1), 27–51. Available at: http://www.issbs.si/press/ISSN/2232-5697/6_27-51.pdf. Accessed 21.10.2020.
Lazarevic, D., Kautto, P., Antikainen, R., 2020. Finland's wood-frame multi-storey construction innovation system: analysing motors of creative destruction. For. Pol. Econ. 110, 101861. https://doi.org/10.1016/j.forpol.2019.01.006.
Larasatie, P., Guerrero, J.E., Conroy, K., Hall, T.E., Hansen, E., Needham, M.D., 2018. What does the public believe about tall wood buildings? An exploratory study in the US Pacific Northwest. J. For. 11 (5), 429–436. https://doi.org/10.1093/jofore/fvy025.
Lehmann, S., 2013. Low carbon construction systems using prefabricated engineered solid wood panels for urban infill to significantly reduce greenhouse gas emissions. Sustainable Cities and Society 6, 57–67.
Lessing, J., Brege, S., 2018. Industrialized building companies' business models: multiple case study of Swedish and north American companies. J. Construct. Eng. Manag. 144 (2) https://doi.org/10.1061/(ASCE)CO.1943-7862.0001368.
Lähtinen, K., Harju, C., Toppinen, A., 2019. Consumers' perceptions on the properties of wood affecting their willingness to live in and prejudices against houses made of timber. Wood Mater. Sci. Eng. https://doi.org/10.1080/17480272.2019.1615548.
Ma, Y., Rong, K., Mangalagiu, D., Thornton, T.F., Zhu, D., 2018. Co-evolution between urban sustainability and business ecosystem innovation: evidence from the sharing mobility sector in Shanghai. J. Clean. Prod. 188 (1), 942–953. https://doi.org/10.1016/j.jclepro.2018.03.323.
Mahapatra, K., Gustavsson, L., 2008. Multi-storey timber buildings: breaking industry path dependency. Build. Res. Inf. 36 (6), 638–648. https://doi.org/10.1080/09613210802386123.
Martek, I., Hosseini, R., Shrestha, A., Edwards, D., Seaton, S., Costin, G., 2019a. End-user engagement: the missing link of sustainability transition for Australian residential buildings. J. Clean. Prod. 224, 697–708.
Martek, I., Hosseini, R., Shrestha, A., Edwards, D., Durdyev, S., 2019b. Barriers inhibiting the transition to sustainability within the Australian construction industry: an investigation of technical and social interactions. J. Clean. Prod. 211, 281–292.
Masucci, M., Brusoni, S., Cennamo, C., 2020. Removing bottleneck in business ecosystems: the strategic role of outbound open innovation. Res. Pol. 49 (1), 103823. https://doi.org/10.1016/j.respol.2019.103823.
Matinaro, V., Liu, Y., 2017. Towards increased innovativeness and sustainability through organizational culture: a case study of a Finnish construction business. J. Clean. Prod. 142, 3184–3193.
de Meyer, A., Williamson, P.J., 2020. Ecosystem Edge: Sustaining Competitiveness in the Face of Disruption. Stanford University Press, Stanford, California, p. 224. ISBN: 9781503610217 (cloth), 9781503611863 (electronic).
Mokhlesian, S., Holmén, M., 2012. Business model changes and green construction processes. Construct. Manag. Econ. 30 (9), 761–775. https://doi.org/10.1080/01446193.2012.694457.
Moore, J.F., 1993. Predators and prey: a new ecology of competition. Harv. Bus. Rev. 71 (3), 75–86.
Moore, J.F., 1998. The rise of a new corporate form. Wash. Q. 21 (1), 167–181. https://doi.org/10.1080/01636609809550301.
Moore, J.F., 2006. Business ecosystems and the view from the firm. Antitrust Bull. 51, 31–75.
Nejat, P., Jomehzadeh, F., Taheri, M.M., Gohari, M., Majid, M.Z.A., 2015. A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries). Renew. Sustain. Energy Rev. 43, 843–862.
Paquin, R.L., Howard-Grenville, J., 2013. Blind dates and arranged marriages: longitudinal processes of network orchestration. Organ. Stud. 34 (11), 1623–1653. https://doi.org/10.1177/0170840612470230.
Pemsel, S., Widén, K., Hansson, B., 2010. Managing the needs of end-users in the design and delivery of construction projects. Facilities 28 (1/2), 17–30. https://doi.org/10.1108/02632771011011378.
Pulkka, L., Ristimäki, M., Rajakallio, K., Junnila, S., 2016. Applicability and benefits of the ecosystem concept in the construction industry. Construct. Manag. Econ. 34 (2), 129–144. https://doi.org/10.1080/01446193.2016.1179773.
Ruuska, A., Häkkinen, T., 2016. Efficiency in the delivery of multi-story timber buildings. Energy Procedia 96, 190–201. https://doi.org/10.1016/j.egypro.2016.09.120.
Thomas, L.D.W., Autio, E., 2014. The fifth facet: the ecosystem as an organizational field. Acad. Manag. Proc. 2014 (1) https://doi.org/10.5465/AMBPP.2014.10306abstract, 10306–10306.
Toppinen, A., Röhr, A., Pätäri, S., Lähtinen, K., Toivonen, R., 2018. The future of wooden multistory construction in the forest bioeconomy - a Delphi study from Finland and Sweden. J. For. Econ. 31, 3–10. https://doi.org/10.1016/j.jfe.2017.05.001.
Toppinen, A., Miilumäki, N., Vihemäki, H., Toivonen, R., Lähtinen, K., 2019. Collaboration and shared logic for creating value-added in three Finnish wooden multistorey building projects. Wood Mater. Sci. Eng. 14 (5), 269–279.
Tunn, V.S.C., Bocken, N.M.P., van den Hende, E.A., Schoormans, J.P.L., 2019. Business models for sustainable consumption in the circular economy: an expert study. J. Clean. Prod. 212, 324–333.
Valkokari, K., 2015. Business, innovation and knowledge ecosystems: how they differ and how to survive and thrive within them. Technology Innovation Management Review 5 (8), 17–24. https://doi.org/10.22215/timreview/919.
de Vasconcelos Gomes, L., Figueiredo Facin, A., Salerno, M., Ikenami, R., 2018. Unpacking the innovation ecosystem construct: evolution, gaps and trends. Technol. Forecast. Soc. Change 136, 30–48. https://doi.org/10.1016/j.techfore.2016.11.009.
Viholainen, N., Kylkilahti, E., Autio, M., Toppinen, A., 2020. A home made of wood: consumer experiences of wooden building materials. Int. J. Consum. Stud. (in press).
Vischer, J.C., 2008. Towards a user-centred theory of the built environment. Build. Res. Inf. 36 (3), 231–240. https://doi.org/10.1080/09613210801936472.
Wang, L., Toppinen, A., Juslin, H., 2014. The use of wood in green building: a study of expert perspectives from the UK. J. Clean. Prod. 65, 350–360.
Weiss, G., Pelli, P., Orazio, C., Tykkä, S., Zivojinovic, I., Ludvig, A., 2017. Forest industry clusters as innovation systems: analysing innovation support frameworks in five European regions. Austrian Journal of Forest Science 134 (2), 119–148.
Williamson, P.J., de Meyer, A., 2012. Ecosystem Advantage: how to successfully harness the power of partners. Calif. Manag. Rev. 55 (1), 24–46. https://doi.org/10.1525/cmr.2012.55.1.24.
Wulf, A., Butel, L., 2017. Knowledge sharing and collaborative relationships in business ecosystems and networks - a definition and a demarcation. Ind. Manag. Data Syst. 117 (7), 1407–1425. https://doi.org/10.1108/IMDS-09-2016-0408.